SECRET
(When Filled In)

CONTRACT INSPECTION REPORT

CONTRACT NO. [redacted] TASK NO.

25X1

TO:

ENGINEERING SECTION/CB/PD/OL

DATE
29 Aug 64

INSPECTION REPORT NO. (If final, so state)
9

ESTIMATED COMPLETION DATE
Oct. 64

NAME OF CONTRACTOR

Declass Review by NGA.

25X1

[redacted]

TYPE

Extension of perception applicability to automatic photo interpretation

THE CONTRACTOR IS ON SCHEDULE ☐ YES ☒ NO

PER CENT OF WORK COMPLETED 95%

THE CONTRACTOR WILL PROBABLY REMAIN WITHIN ALLOCATED FUNDS ☒ YES ☐ NO IF ANSWER IS "NO" ADVISE RECOMMENDATION AND/OR ACTION OF SPONSORING OFFICE, ON REVERSE HEREOF. IF KNOWN, INDICATE MAGNITUDE OF ADDITIONAL FUNDS INVOLVED.

HAS AN INTERIM REPORT, FINAL REPORT, PROTOTYPE, OR OTHER END ITEM BEEN RECEIVED FROM THE CONTRACTOR DURING THE PERIOD? ☒ YES ☐ NO (If yes, give details on reverse side.)

Monthly and interim reports were received.

HAS GOVERNMENT-OWNED PROPERTY BEEN DELIVERED TO CONTRACTOR DURING THIS PERIOD? ☐ YES ☒ NO (If yes, indicate items, quantity, and cost on reverse side.)

Final report is in publication - ONR has granted two month extension.

OVERALL PERFORMANCE OF CONTRACTOR

1. ☐ OUTSTANDING
2. ☐ EXCELLENT
3. ☐ ABOVE AVERAGE
4. ☒ AVERAGE
5. ☐ BELOW AVERAGE
6. ☐ BARELY ADEQUATE
7. ☐ UNSATISFACTORY

IF OVERALL PERFORMANCE OF CONTRACTOR IS UNSATISFACTORY OR BARELY ADEQUATE, INDICATE REASONS ON REVERSE SIDE.

RECOMMENDED ACTION

☒ CONTINUE AS PROGRAMMED

☐ WITHHOLD PAYMENT PENDING SATISFACTORY PERFORMANCE

☐ TERMINATE

☐ OTHER (Specify)

IF TERMINATION IS RECOMMENDED OR IF THIS IS A FINAL REPORT ATTACH COMMENTS IN NARRATIVE FORM ON CONTRACTOR'S PERFORMANCE AND CERTIFY THAT ALL DELIVERABLE ITEMS UNDER THE CONTRACT HAVE BEEN RECEIVED. THESE INCLUDE, WHERE APPLICABLE, THE FOLLOWING:

ITEM	REC'D	DOES NOT APPLY	ITEM	REC'D	DOES NOT APPLY
PROTOTYPES			MANUALS		
DRAWINGS AND SPECIFICATIONS			FINAL REPORT		
PRODUCTION AND/OR OTHER END ITEMS			SPECIAL TOOLING		
			OTHER GOVERNMENT PROPERTY		

25X1

DATE OF LAST CONTACT WITH CONTRACTOR

[redacted]

FORM 6-64 1897 PREVIOUS EDITION (12-36)

SECRET
(When Filled In)

Excluded from automatic downgrading and declassification

25X1

[redacted]

File

Investigation of Perceptron Applicability to Photo Interpretation

25X1

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Semi-Annual Status Report for
the period ending 1 June 1964

25X1

Prepared by: Approved by:

[redacted]

GCV:6-rc
File: PICS D03-420

Semi-Annual Status Report

Investigation of Perceptron Applicability to Photo Interpretation

Semi-Annual Report for
period ending 1 June 1964

1.0 INTRODUCTION

Project PICS is an investigation of the applicability of perceptrons to the automation of certain portions of the photo interpretation task. The objectives of the project were changed during the last semi-annual period in the direction of developing equipment closer to the stage of practical implementation as an aid to photo interpreters. The Mark III Spatial Filtering device was designed, built, and tested during this period to satisfy the "practical implementation" goal. The main areas of effort during the period covered by this report have been the following.

1) Development and implementation of techniques for whole-photo classification applicable to the rejection of sterile photographs.

2) Development and implementation of techniques for the detection and isolation of objects contained in photographs.

3) Theoretical and experimental evaluation of the properties which can be derived by optical spatial filtering.

4) Design and implementation of a recognition system based on property generation using optical spatial filtering.

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2.0 TECHNICAL ACCOMPLISHMENTS TO JUNE 1964

2.1 Recognition Studies

The ordinary viewpoint of the weight derivation (training) process of a perceptron is that of moving a plane in the binary n-space defined by the A-unit activities, such that the members of two classes are separated. Several new insights into the problem are available if one considers the dual problem. That is, we define the space of interest by the A-unit weights. In this space, each stimulus is a hyperplane and a set of weights is a point. A solution is represented by any point within a convex region determined by the stimulus planes and their required classification.

Because of the convexity of the solution region (if it exists) many properties of the set of solution are immediately apparent. For example, given W_1 and W_2 any two weight vectors which are solutions, then $aW_1 + (1-a)W_2$ is also a solution for all $1 > a > 0$.

Using these new (to perceptron theory) concepts a new method of training was postulated. It depended upon successive relaxation of the boundaries of the solution region, followed by a step toward the interior of the region. Several trial examples showed that no simple method known to the experimenters will yield a step toward the interior of the region when the current trial point is at a vertex of order higher than two. Since this is an extremely likely event at an early stage in the solution, work on this particular training method has been suspended.

It is expected that the really very fruitful dual viewpoint may yield additional new techniques for trial. A particular problem that may well be attacked from this outlook is that of effective discovery of training problems which have no perfect solution. We also hope to shed some light on the multiple solution problem.

Synthetically generated patterns which have been previously used for recognition studies were used in a new set of experiments to obtain the effects of the additional distortions produced by the isolation and standardization processes. These additional distortions are produced because the figures are often torn into several pieces by the noise generation process.

A 500 A-unit perceptron was trained to recognize all aircraft in a large sample of these patterns. A different set of 866 patterns was used to test its performance. There were 42 classification errors (4.8%) in this experiment. This is to be compared with no errors in a set of 720 patterns in previous experiments which did not use isolation and standardization.

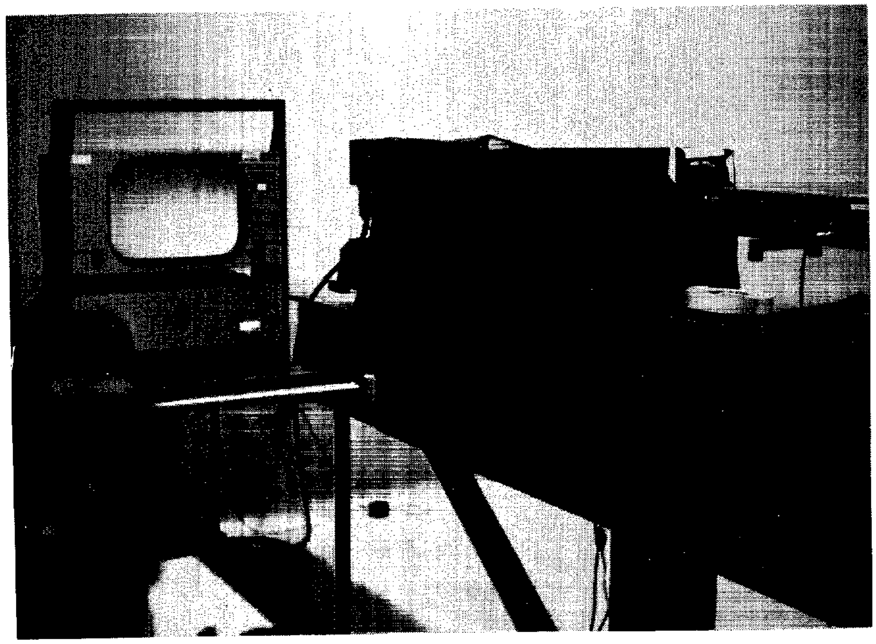
Upon examination of the types of errors which were made, it seemed possible that inclusion of a scale-factor objective property would lower the error rate. An experiment showed that this was a false hope. Hindsight indicates that the patterns which were not aircraft were both smaller and larger than the aircraft, and thus a scale factor property could not aid linear separability.

2.2 Implementation (Mark III)

The first design approach was an electronic system for a spatial spectrum analyzer generating video signals with adjustable boundary conditions. The amplitude of the video signal would be controlled as a function of the position of the scanning beam on the raster. The video signals are then integrated to produce a control signal corresponding to the average brightness, modified by the position control function, of the picture within the specified boundary. This design was not implemented.

The first design and first equipment set-up consisted of a mercury light source, pinhole, collimator and object lenses, test transparencies, and a Kintel closed-loop television system. The original experiments determined the need of a low frequency circular occluding filter to improve high spatial frequency sensitivity. The inefficient pinhole collimator light system did not provide detectable light levels in the high spatial frequency region. This type of collimated light was replaced by a CW-laser (6328 A) source in the final version of the Mark III. See Fig. 1 for experimental set-up.

A desire to further explore the possibilities of picture content-detection by spatial spectrum analysis led to a decision to construct an experimental apparatus of somewhat different form than that described above. The first design was aimed at extraction of many spatial properties



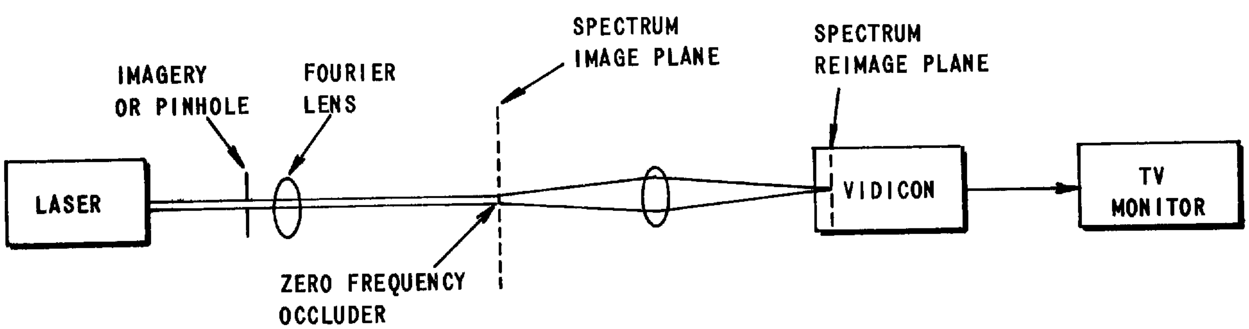


Figure 1 SPATIAL FILTER EXPERIMENTAL SETUP "A"

essentially simultaneously for a single area in a photo, by use of electronic gating of the signal produced by the vidicon. This is still the preferred technique for both research studies and application, but has the drawback of requiring considerable electronic design and construction before any results can be obtained.

The final experimental apparatus extracted one property at a time from many areas of the photo, the areas being selected by a simple mechanical scanning mechanism. (See Fig. 2). The property to be measured is generated by a slide used as a spatial filter, followed by a conventional photomultiplier sensor. The output display consists of a laboratory oscilloscope, synchronized to the scanning mechanism. An automatic slide changer, which is in line with the optical path, allows selection of various filter properties. The typical application of the Mark III is for the detection of areas of a photograph which contain the works of man (as revealed by strong line structures in the power spectrum). In Fig. 3 the block diagram of electronic control for the Mark III is presented, and a photograph of the Mark III apparatus is presented in Fig. 4.

2.1.1 Experimental Results

The experimental results were completed over this report period with three versions of the Mark III apparatus.

Data Groupings

(A) Taken with apparatus shown in Fig. 1

(B) Taken with apparatus shown in Fig. 2

(C) Taken with apparatus shown in Fig. 5

Results of Data Group (A)

This experimental program was aimed at obtaining quantitative measurement of performance, especially dynamic range and sensitivity required. The photographs shown in Fig. 6 were taken of (1) the spatial frequency focal plane, (2) the closed circuit TV monitor, and (3) the video signal for specific horizontal scan lines in the monitor raster. The objective film in this case was a railroad yard.

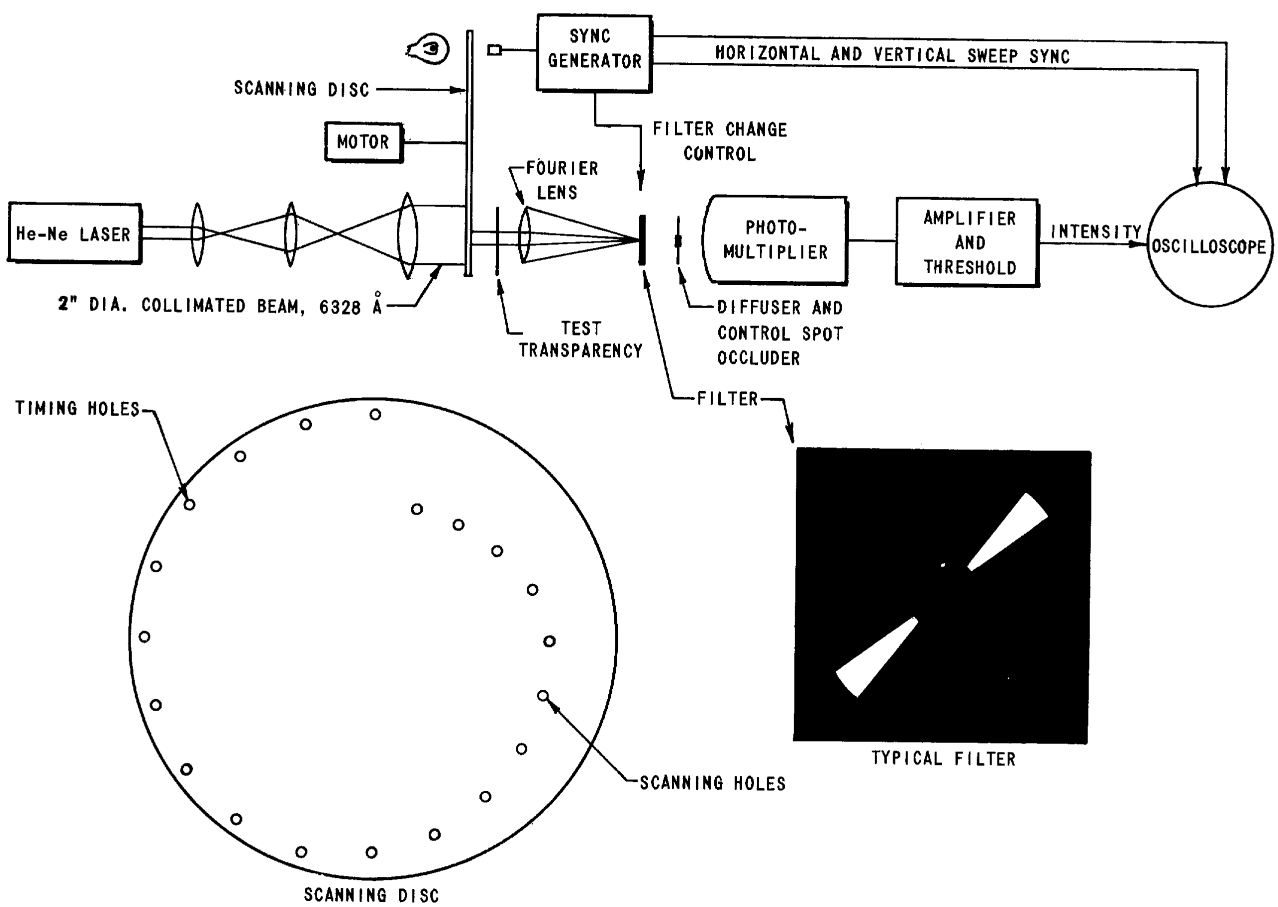


Figure 2 MARK III SPATIAL FILTER RECOGNITION APPARATUS EXPERIMENTAL MODEL

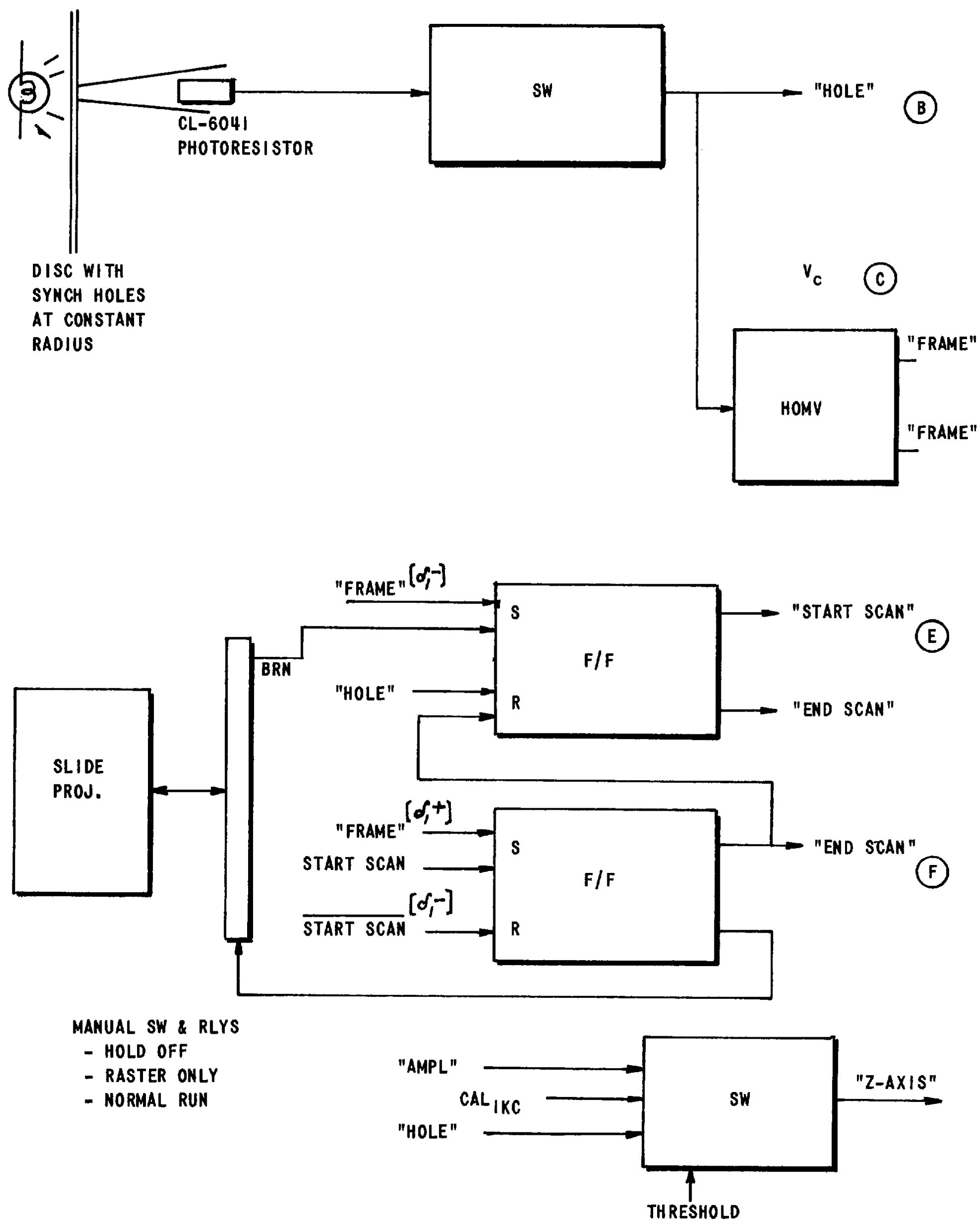
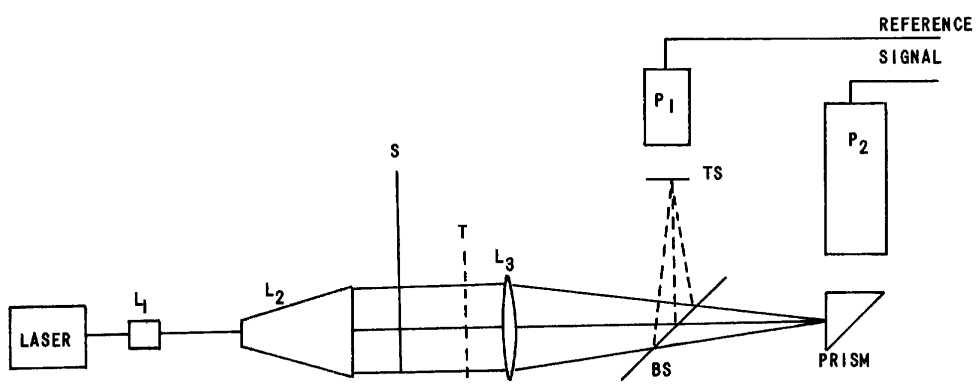


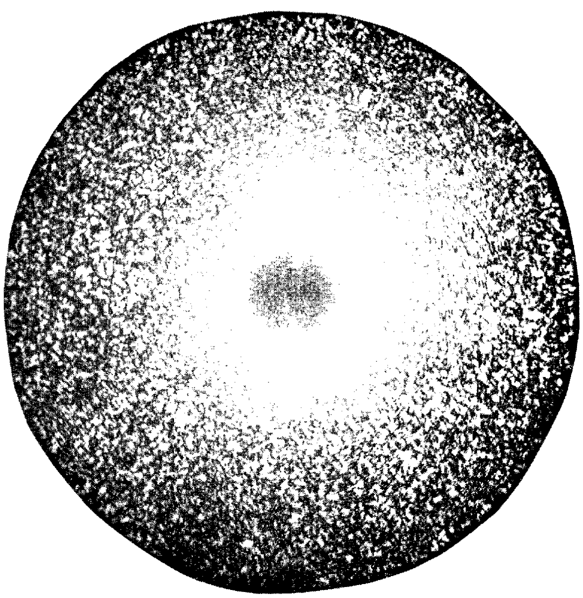
Figure 3 BLOCK DIAGRAM OF ELECTRONIC CONTROL FOR SET-UP B

Figure 4 ELECTRO-OPTICAL EXPERIMENTAL SET-UP "B"

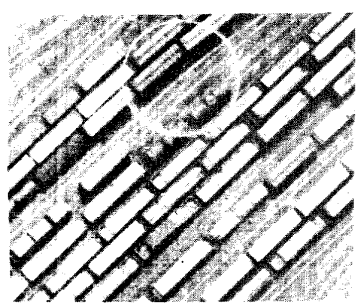


SYMBOL	DESCRIPTION
L_1	LENS - 25MM, f 1.5
L_2	LENS - COLLIMATOR
L_3	LENS - FOURIER
S	SCANNING DISK
T	OBJECT TRANSPARENCY
TS	TRANSLUCENT SHEET
BS	BEAM SPLITTER
P_1	REFERENCE PHOTOMULTIPLIER
P_2	SIGNAL PHOTOMULTIPLIER

Figure 5 OPTICAL CONFIGURATION FOR MODIFIED SET-UP

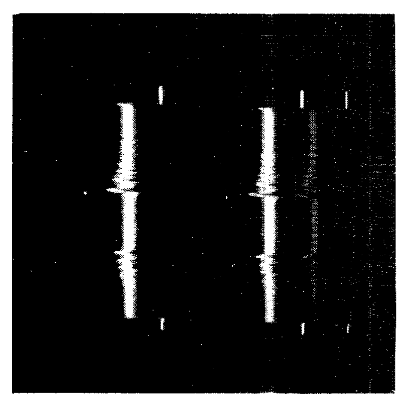


SPATIAL FREQUENCY FOCAL PLANE



R. R. YARD PHOTO

TELEVISION MONITOR



VIDEO SIGNALS OF HORIZONTAL SCAN LINES

Figure 6

BANDPASS OCCLUDING FILTER USED HERE HAS A CENTRAL STOP DISC OF 5.8 MM DIAMETER AND A SURROUNDING STOP INSIDE DIAMETER OF 37 MM; THE PASSBAND IS 7.3 CYCLES/MM TO 47 CYCLES/MM.

THE VIDEO SIGNALS CORRESPOND TO THE RASTER CENTER LINE.

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Results of Data Group (B)

The over-all system displays an intensity modulated raster traced out in synchronism with the collimated beam which scans over an entire object transparency. Intensity modulation occurs for superthreshold diffracted light energy; that is, for each portion of the object transparency that contains spatial frequencies within a wide band AND over threshold, the display raster is intensified. The test results appear in Fig. 7. Using specific 35 mm object slides as standard signal inputs, several photographs of photomultiplier output voltage and display rasters were recorded. Three sets of photographs present the video signals (top to bottom) and the intensified rasters (left to right) correspond to the object transparencies as follows:

1) Nothing
2) Object transparency (reproduced to the right of the CRO photographs)
3) A standard 100 line/inch Ronchi ruling

There were no adjustments of amplifier gains, threshold, etc. within a set of photographs.

Results of Data Group (C)

The equipment set-up was identical to the (B) tests except for the addition of a beam intensity reference level and difference of log functions of the signal and reference outputs. Low pass filtering (0 - 500 c.p.s.) was added to each of the two signal outputs prior to the resistive mixing circuit.

The scope photographs of Fig. 8 show the results of Experiments #1 and #4 of this experimental arrangement. The most successful result is that of experiment number 4 which shows good correlation between the optical image and the scope display.

3.0 FUTURE PLANS

The principal activity will be to prepare a final report covering the research program of the past year.

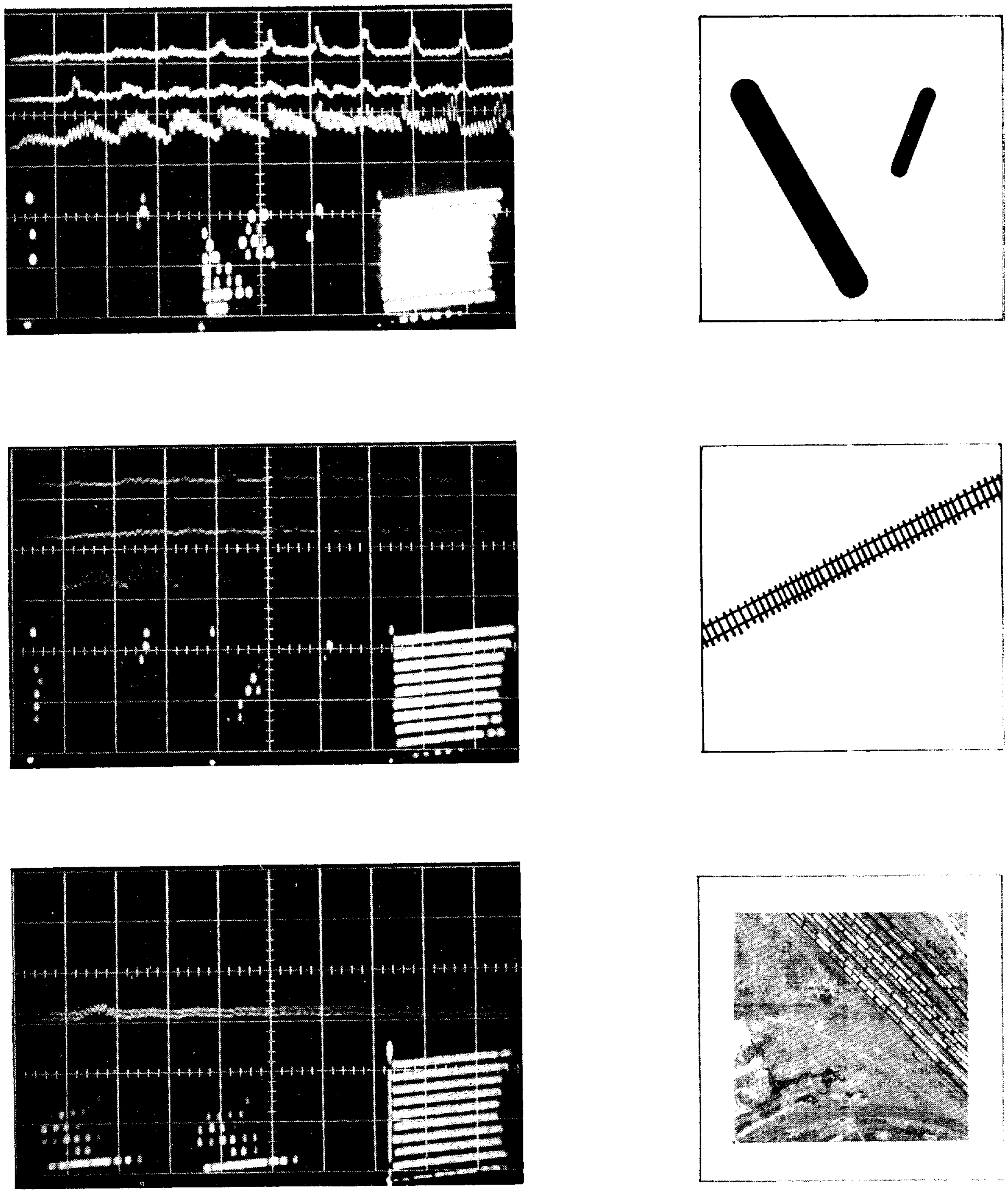
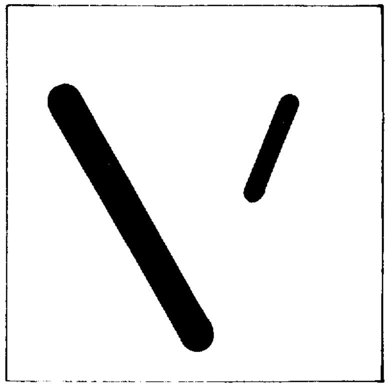
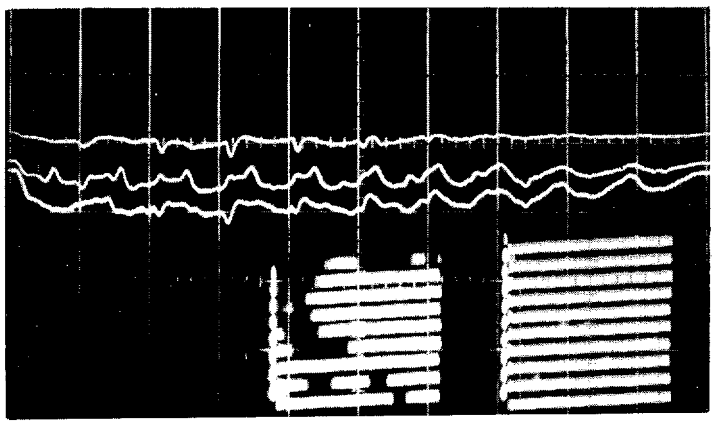


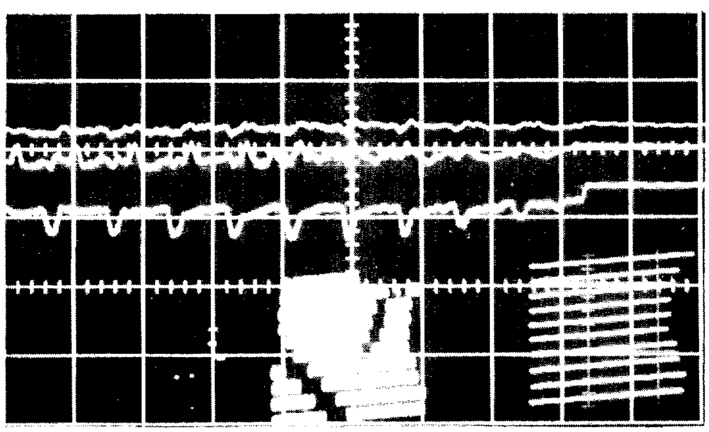
Figure 7 PHOTOGRAPHS OF VIDEO AND RASTERS OBTAINED FROM THE OBJECTS SHOWN



OBJECT SLIDE



EXPERIMENT NO. 1



EXPERIMENT NO. 4

Figure 8 OBJECT SLIDE, CRO TRACES, AND RASTER FOR EXPERIMENTAL RUNS NO. 1 & 4

4.0 REPORTS AND PROJECT PERSONNEL

Reports include the regular monthly letter reports for this period. 25X1

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25X1

Letter Report No. 28

Investigation of Perceptron Applicability to Photo Interpretation

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Monthly Letter Report
for the month of May 1964

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25X1

Letter Report No. 28

Investigation of Perceptron Applicability to
Photo Interpretation

Monthly Letter Report
for the month of May 1964

1.0 INTRODUCTION

Project PICS is an investigation of the applicability of perceptrons to automation of certain parts of the photo interpretation task. Particular emphasis is placed on area and object recognition based upon properties derived from two-dimensional power spectra. Accordingly, effort is centered in the following major areas:

1) Theoretical and experimental evaluation of the properties which can be derived by optical spatial filtering.

2) Design and implementation of a recognition system based upon such properties.

3) Design of optical-electronic spatial filtering equipment.

4) Research based upon ideas whose immediate applicability cannot be stated, but of long-term benefit.

2.0 ACTIVITY AND ACCOMPLISHMENTS DURING MAY 1964

2.1 Property Evaluation

This work was terminated at the end of April.

2.2 Design of Optical Electronic Spatial Filtering Apparatus

The addition of light level correction circuitry to the Mark III optical electronic spatial filter improved the dynamic range when the system was used for spatial line detection. The experiments established feasibility of line segment detection; however, a contrast limit was not determined. The design modifications and tests were terminated during the first two weeks

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of May.

2.3 Recognition Studies

No work was performed in this area during May.

2.4 Final Report

A survey and compilation of the Mark III implementation work was completed and will be included in the final report.

3.0 PLANS FOR JUNE 1964

The principal activity will be to continue the preparation of the semi-annual status report and the final report.

4.0 REPORTS

No reports other than the regular monthly letter report were due or issued during May.